VEHICLE STATE INFORMATION TRANSMISSION APPARATUS USING TACTILE DEVICE

FIELD OF THE INVENTION

[0001] The present invention relates to an apparatus for transmitting vehicle state information to a driver by way of tactile information produced by a tactile device.

BACKGROUND OF THE INVENTION

[0002] Various vehicle state information transmission apparatus or systems for transmitting vehicle state information to a driver as tactile information are known as disclosed in Japanese Patent Laid-open Publications (JP-A) Nos. 2005-182406, 2001-080436, 2005-041471, 2001-010518, and 2006-298166.

[0003] The vehicle state information transmission apparatus disclosed in JP-2005-182406A, as shown in FIG. **30** hereof, takes the form of a lane departure prevention apparatus **501** comprised of a visual external sensor (CCD camera) **502**, a camera (sensor) controller **503**, an electronic control unit ECU including a departure determining section, a warning device **504**, and a brake hydraulic pressure control circuit operatively connected to the ECU and brake units associated with vehicle wheels. When the departure determining section of the ECU, on the basis of information received from the CCD camera **502**, determines that the vehicle tends to cause a lane departure, the ECU controls operations of the brake hydraulic pressure control circuit and the individual brake units to perform a variable brake force control operation in which the brake force acting on each individual vehicle wheel is frequently varied to provide the driver with a departure warning in the form of vibration of a steering wheel shaft **505** of the vehicle and, at the same time, to correct the traveling course in a direction to avoid lane departure. In synchronism with the braking cycle, the warning device **504** (formed by a speaker or a buzzer) provides an audible warning sound to the driver.

[0004] However, the foregoing lane departure prevention apparatus (vehicle state information transmission apparatus) **501** is not fully satisfactory in that when the vehicle is traveling along a road with irregular road surface while passing in loud environments or playing an audio device at top volume, both the vibratory motion of the steering wheel shaft **505** and the audio warning from the warning device **504** cannot be clearly perceived by the driver.

[0005] FIG. **31** hereof shows the vehicle state information transmission apparatus disclosed in JP 2001-080436A. The disclosed apparatus takes the form of a vehicle warning apparatus **551**, which comprises a doughnut-shaped rubber tube **553** arranged around a recessed peripheral portion of a steering wheel **552**, and a variable pressure control device **554** connected to the rubber tube **553** for variably controlling the internal pressure of the rubber tube **553** in accordance with a command signal from an ECU so that when lowering of the tire pressure is detected, the variable pressure control device **554** operates to repeatedly increase and decrease the internal pressure of the rubber tube **553** to thereby generate minute vibration. The thus generated minute vibration is directly transmitted to the driver's hand as tactile low-tire-pressure warning information.

[0006] The vehicle warning apparatus (vehicle state information transmitting apparatus) **551** of the foregoing construction, however, necessarily involves a response time lag problem due to the use of a working fluid.

[0007] The vehicle state information transmission apparatus disclosed in JP 2005-041471A takes the form of a vehicular travel safety device configured such that the likelihood of a rear-end collision is determined by calculation based on an inter-vehicle distance determined by using a radar, and when the likelihood of a rear-end collision is determined to be critically high, a seatbelt device is automatically operated to repeatedly tighten a seatbelt and release the tightening of the seatbelt. With this arrangement, however, since a rear-end collision warning is provided to the driver by way of vibrations produced by repeated tightening of the seatbelt, a reliable perception of such vibratory warning cannot be expected for a pregnant woman driver who has no obligation to fasten a seatbelt, or a driver thickly dressed with a winder sweater and a down-jacket.

[0008] The vehicle state information transmission apparatus disclosed in JP 2001-010518A takes the form of a vehicle steering control device serving as a lane keep assistance device. The steering control device is arranged such that when the vehicle is traveling at the center of a drive lane, a small steering reaction force is provided to the driver via a steering wheel, and when the vehicle deviates or offsets leftward or rightward from the drive lane center, the steering reaction force transmitted via the steering wheel to the driver is increased to thereby providing the driver with a sensation as if the vehicle drifts across the drive lane in a direction to take up the lane deviation. However, the thus arranged vehicle state information transmission apparatus (lane keep assistance device) is disadvantageous in that increasing the steering reaction force to take up a lane departure of the vehicle will require a measurable amount of electric power if the steering reaction force is electrically produced, or involve high fuel consumption if the steering reaction force is hydraulically produced. Furthermore, due to the presence of surface irregularities, undulations, or ruts on the road surface, it is difficult for the driver to perceive whether the steering reaction force is produced by either the lane keep assistance device or the road surface profile.

[0009] FIGS. **32**A to **32**D hereof diagrammatically illustrate operation of the vehicle state information transmission apparatus disclosed in JP 2006-298166A. The disclosed apparatus **501** includes a tactile device **504** assembled in a vehicle steering wheel (only a flexible skin layer **503** being shown) at around the 3-o'clock position for being gripped with the right hand H of the driver. Though not shown, a similar tactile device is incorporated in the steering wheel at around the 9-o'clock position for being gripped with the driver's left hand. The tactile device **504** includes a rectangular array of actuator pins (not shown) arranged in rows X**1**-X**4** and columns Y**1**-Y**4** and individually drivable to undergo axial reciprocation to form a series of projections **505**-**508** on a front surface of the flexible skin layer **503** of the steering wheel. When the driver turns the steering wheel counterclockwise (leftward in FIG. **32**A) to steer the vehicle **502** leftward, the actuator pins of the tactile device **504** operate such that a series of projections formed on the front surface of the flexible skin layer **503** of the steering wheel in parallel with the circumferential direction of the steering wheel shifts stepwise (or column by column) in a radial outward direction of the steering wheel as at **505**-**508** shown in FIG. **32**A-**32**D. The thus shifting projections **505**-**508** produce a wavy motion advancing in the radial outward direction of the steering